„Probabilistic entropy in engineering computations”

The main subject of this research project is determination of probabilistic entropy in practical problems related to civil engineering, mechanical and materials engineering as well as aeronautics. As it is known, probabilistic entropy is an universal measure of statistical dispersion of the analyzed state variables and the alternative to classical probabilistic parameters such as standard deviation, coefficient of variation or statistical correlation. A literature concerning mechanics and stochastic analysis still brings relatively small number of elaborations related to determination of numerical values and parametric variability of probabilistic entropy in engineering problems and the purpose of the proposed project is to change the available knowledge state in this area. In the scope of this project numerical implementations of entropy definitions proposed by Shannon, Renyi, Tsallis, Sinai and Kullback-Leibler will be created and explored for both discrete and continuous probability distributions. Computer simulations of the entropy and its fluctuations resulting from various material, physical and geometrical uncertainty sources will be carried out with the use of crude and interval Monte-Carlo simulation, iterative generalized stochastic perturbation technique as well as semi-analytical method. A principal research hypothesis verified in this project states that probabilistic entropy can be determined numerically in many areas and problems of modern engineering with a priori given numerical error and, that it can serve for an influence of parameter uncertainty in these problems on structural response of the modelled structures or systems. It will be demonstrated that such an entropy may be efficiently used for reliability assessment of many important engineering systems.

Various sources of uncertainty will be considered having Gaussian, Weibull, Poisson and Gumbel distributions as well as triangular, uniform, log-normal, exponential and power probability distribution functions. These distributions will be used to model such structural and system parameters as elasticity modulus, plastic limit, strength, environmental and technological loads as well as lengths, thicknesses and connections of structural elements together with their imperfections. Probabilistic entropy and their variations will be determined in several uncoupled problems of linear and nonlinear elasticity, elasto-plasticity, elastic and inelastic stability, nonstationary heat transfer as well as forced vibrations. The solutions of the few coupled problems related to thermo-elasticity, heat and fluid flow described by Navier-Stokes equations as well as thermo-electro-magneto-elasticity are planned in this project. Some homogenization problems of the few composite materials as well as optimization problems of skeletal steel structures will be solved too. The resulting probabilistic entropy will be computed for deformations and stresses, temperatures, effective material and physical parameters, fluid velocities and pressures as well as eigenfrequencies and dynamic fluctuations of displacements. Stochastic Finite Element Method, Stochastic Boundary Element Method, Stochastic Finite Difference Method and also Stochastic Finite Volumes Method will be used as stochastic extensions of the well-known numerical methods. Probabilistic entropy and its fluctuations in these problems will be compared with the basic probabilistic characteristics of the resulting state functions; numerical error analysis related to entropy determination according to various theories and computer method will be analyzed too.